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Memorandum

SUBJECT: Update: Exposure Assessment for Chlorpyrifos Post-Construction Termiticide Use DP Barcode D266827, Case 818975, PC Code 059101).

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This memo addresses the potential exposure to chlorpyrifos resulting from treatment of four different housing types (slab, crawlspace, basement and plenum) for the control of termites. This assessment updates the previous exposure assessment conducted in 1988 (memo from M. Firestone, Chief, Special Review Section, Exposure Assessment Branch, Hazard Evaluation Division, to D. Edwards, Product Manager, #12, Registration Division, June 29, 1988, Reg/File # 464-562, EAB # 60271, 80628). Specifically, this analysis calculates house-specific chlorpyrifos air concentrations over time to better represent the potential exposure to residents. Both 90 day and 1 year incremental time-weighted average (TWA) concentrations were calculated for each house.

The chlorpyrifos registrants agreed to risk mitigation measures in June 2000. Part of the mitigation for the termiticidal use involved reducing the concentration of chlorpyrifos from 1%

ai to 0.5% ai. Effects of this mitigation are presented in this exposure assessment.

Exposure Assessment for Post-Construction Treatments:

A study submitted by the registrant (MRID No. 40094001) was used to determine the respiratory exposures of the residents of homes treated with chlorpyrifos (approximately 0.6-1.3% ai Dursban TC) for subterranean termite control. Thirty one homes, 8 each of crawlspace, slab, and basement construction, and 7 plenum homes were treated at several different locations throughout the country. Applications were made by licensed professional applicators using conventional equipment and following the label instructions. Air in the kitchen, one bedroom, and the basements of basement construction homes was monitored before treatment and at various intervals after application for one year (i.e., during treatment, at 2, 4, 8, and 24 hours, 7, 30, and 90 days and 1 year post treatment).

The air measurements for each home are presented in Appendix A by housing type. Airborne chlorpyrifos was sampled using glass absorber tubes containing Chromosorb 102 packing. Air was pulled through the tubes at the rate of approximately one liter per minute using portable battery operated pumps. The sampling time was two hours per session. The median 90 day and 1 year incremental time-weighted average (TWA) concentrations are presented in Appendix A.

Treatment of homes with chlorpyrifos for subterranean termite control appears to result in a slightly increased chlorpyrifos air concentrations over pre-treatment levels soon after treatment. More than half (55% or 17/31) of the homes had detectable chlorpyrifos air concentrations at levels ranging from <0.06 to $2.3 \mu\text{g}/\text{m}^3$ before treatment. The highest pre-treatment concentration of $2.3 \mu\text{g}/\text{m}^3$ measured in a slab house is higher than all the post-treatment 1 day maximum concentrations except for 3 homes (2 plenum and 1 slab which is the same house). Air concentrations returned to pre-treatment levels within a few days after the application for slab, crawlspace, and the first floor rooms of basement homes. Basements showed higher concentrations of the chemical than first floor rooms. The concentrations in basements declined slowly over time, reaching first floor air measurement levels within one year after application. Treatment of plenum structures appears to result in airborne concentrations in first floor rooms that are slightly higher than those observed in other construction types. These increased levels return to pre-treatment levels within a few months after application.

Exposure Parameters:

Adults and children were assumed to be indoors in a residence (or treated buildings) for 16.4 and 20 hours per day, respectively. These exposure durations represents the 50th percentile for time spent at indoors for all individuals and the weighted average for children ages 1 to 6 years of age, respectively (USEPA 1997). Respiratory volumes for adults and children (13.3 and $8.1 \text{ m}^3/\text{day}$) were also obtained from USEPA (1997). The adult value is the average of males and females, while the child value is the weighted average for children ages 1-6 years.

Air Concentrations:

Tables 1 and 2 present the 90 day and the 1 year incremental TWA concentrations including risk mitigation and excluding risk mitigation, respectively. Based on the mitigation plan agreed to by chlorpyrifos registrants in June 2000, HED calculated the incremental TWAs by adjusting the air measurements associated with a 0.6-1.3% ai product application shown in Table 2 to 0.5% assuming that there is a linear relationship between percent ai and resulting air concentrations. Both median and range of values are presented for the 7-8 homes per construction type. The 90 day and 1 year incremental TWAs represent an average concentration across rooms (i.e., kitchen, bedroom and basement) for each house, and across time periods (i.e., 1, 7, 30, 90 for 90 day TWA and 1, 7, 30 90 and 365 day average for 1 year TWA) for each house. The median value of the 7-8 houses is presented, along with the lowest and highest average from a single house. HED used of one-half detection limit (limit of detection was approximately $0.07 \mu\text{g}/\text{m}^3$) for non-detects in calculating both the 90-day and 1-year incremental TWA concentrations. This assumption may overestimate exposures slightly, particularly for the 1 year TWA estimates. However, this assumption is not likely to have a significant impact on the overall risk estimates, and has no impact on the homes with highest air concentrations (those homes had no non-detectable samples).

In order to evaluate the air concentrations exclusively associated with termiticide treatment, HED subtracted the pre-treatment air concentrations from the first seven days. In instances when the pre-treatment sample concentration was greater than any concentration in the first seven days, an air concentration of zero was assumed for the first seven days. The duration of 7 days was selected based on results from another DAS study that showed detectable chlorpyrifos air levels up to 7 days following crack and crevice treatment. The incremental TWA concentration was calculated by assuming a linear relationship of the air concentration between two sampling intervals (e.g., between day 7 and day 30).

Results:

As shown on Table 1, the median 90 day incremental TWA air concentrations, adjusted for application using 0.5% ai, ranged from 0.1 to $0.14 \mu\text{g}/\text{m}^3$, while the median 1 year incremental TWA air concentrations were slightly lower and ranged from 0.07 to $0.13 \mu\text{g}/\text{m}^3$. The incremental TWA air concentrations prior to risk mitigation measures are shown on Table 2 and are approximately two times higher than the mitigated air concentrations. There was considerable variability in air measurements, especially for plenum homes. For example as shown in Appendix A, one plenum house had significantly higher air concentrations of 4.7 to $7.23 \mu\text{g}/\text{m}^3$ up to 7 days, but less product (only 60 gallons) of a 1% ai solution was applied relative to the other plenum homes (90 to 200 gallons applied). Incomplete sampling data were available for the 7 plenum homes evaluated, where only 3 homes were sampled up to 1 year, 2 homes up to 90 days, and one each up to 7 or 30 days. HED notes that the plenum home for

which sampling ceased at 7 days (P7) had the highest, 7-day average air concentration of any home in this study. Similarly, the plenum home for which sampling ceased at 30 days (P6) had the second highest 30 day average air concentration in the study. The registrant did not provide an explanation for the lack of air samples for these 4 plenum homes. The highest TWA air concentration measured at 1 year post application in this study was $0.46 \mu\text{g}/\text{m}^3$ in a basement home.

Studies in the published literature measured air concentrations (average of kitchen and bedroom) of $1.38\text{-}3.13 \mu\text{g}/\text{m}^3$ for crawlspace homes and $2.76\text{-}3.05 \mu\text{g}/\text{m}^3$ for slab homes at 1 year postapplication (Wright et al. 1988). In comparison, the houses with the highest 1 year incremental TWA concentrations from the DAS study had levels of 0.477 and $0.433 \mu\text{g}/\text{m}^3$ for crawlspace and slab, respectively which are significantly lower than the literature values. Average chlorpyrifos concentrations of 0.1 to $0.3 \mu\text{g}/\text{m}^3$ were detected up to 8 years postapplication in slab and crawl homes (Wright et al. 1994). Higher air concentrations were detected in the bedroom, relative to the kitchen 8 years post application. However, these studies did not control for use of other chlorpyrifos products (i.e., lawn treatment, flea control, or other indoor uses, etc) (personal communication by D. Smegal with G. Dupree 5/17/2000), and therefore, may also overestimate potential exposures and risks associated with the termiticide use exclusively.

It should be noted that all of these studies only evaluate exposures resulting from treatment of soil outside the home, and do not evaluate the potentially higher exposures that could result from indoor treatment of a termite infestation (i.e., treating indoor exposed wood beams, baseboards, void injections, etc).

Based on the TWA air concentrations, and exposure assumptions, HED calculated margin of exposures (MOEs) that compare the no-observed-adverse effect level (NOAEL) to the chlorpyrifos exposure estimates. The MOEs are shown in Tables 1 and 2 with mitigation and without mitigation, respectively. MOEs were calculated for both intermediate (90 day) and long-term (1 year) exposure durations due to uncertainties in the toxicity endpoints for both durations. The assumptions and equations used to calculate the MOEs are shown in the footnotes on Tables 1 and 2.

Risk Characterization and Uncertainty Analysis

Because of chlorpyrifos' extensive use as a termiticide, HED has provided a detailed summary of the uncertainties associated with the risk estimates for termiticide treatments. As noted previously, HED calculated incremental TWA air concentrations for the entire house, assuming an individual could be in any room. Based on this assessment, inhalation exposure was the primary concern. Based on the mitigation plan, the incremental TWA air concentrations were normalized to a reduced application rate of 0.5% ai. The MOEs based on risk mitigation are presented on Table 1, while the MOEs based on actual air measurements from the DAS study are presented in Table 2. As part of risk characterization, the Agency evaluated risks for both

intermediate and long-term exposures because of uncertainties in the toxicity endpoints for both durations.

Children 1-6 years of age have higher potential exposures than adults, primarily because of a higher breathing rate per body weight, and data that indicate young children spend more time at home than adults. For children, all of the 90-day median MOEs are greater than 1000 with risk mitigation (median MOEs range from 1,900 to 3,800). Only 5 of the 30 homes with sufficient data have estimated 90-day MOEs less than 1000 for children with risk mitigation. However, some of the 1-year median MOEs are below 1000, even with risk mitigation (median MOEs range from 530 to 1,100). Twenty of the 30 homes with sufficient data have estimated 1-year MOEs less than 1000 for children with risk mitigation. As shown on Table 1, the lowest 90-day and 1-year MOEs for an individual house are 440 and 270, respectively.

The median MOEs for adults were greater than 1000 for all housing types for both the 90-day and 1-year analysis (MOEs range from 1,800 to 13,000) with risk mitigation.

There are however, a number of uncertainties in the risk assessment that arise from the following sources: choice of toxicological data used to establish the inhalation toxicity endpoint, chlorpyrifos air concentrations, and exposure assumptions. The most significant uncertainties will be discussed below.

Toxicity Endpoints: There are uncertainties associated with both the intermediate and long-term inhalation NOAELs used to calculate the MOEs. The intermediate-term NOAEL of 0.1 mg/kg/day is based on two 90-day inhalation studies, in which the rats were exposed 6 hours/day, 5 days/week (nose-only) to the highest attainable vapor concentration of chlorpyrifos ($287 \mu\text{g}/\text{m}^3$). HED could not identify an inhalation LOAEL because no adverse effects were noted at the highest dose tested. Therefore, HED selected an oral LOAEL of 0.3 mg/kg/day to use in the dose-response assessment. The 3 fold difference between the NOAEL and LOAEL, adds an extra buffer of safety to the intermediate-term inhalation endpoint for a total MOE of at least 3000. Although the inhalation route of exposure is ideal for this assessment, the exposure regimen does not fully mimic the potentially continuous inhalation exposure for children associated with a termiticide treatment (i.e., up to 20 hours/day).

The long-term NOAEL of 0.03 mg/kg/day is based on oral animal studies that observed cholinesterase inhibition at 0.2 to 0.3 mg/kg/day (the LOAEL). HED notes that the large difference between the NOAEL and LOAEL (i.e., factor of 6.7 to 10), adds an extra buffer of safety to the long-term inhalation endpoint. Therefore, relative to the LOAEL, the MOE is actually at least 6,000 to 10,000 for a target MOE of 1000. In addition, there are significant uncertainties associated with route-to-route extrapolation due to differences in pharmacokinetics. Following oral exposure, chlorpyrifos is absorbed in the gastrointestinal tract and is transported to the liver, where it can undergo biotransformation to a potent cholinesterase inhibitor (chlorpyrifos-oxon), and be further detoxified. However, following inhalation exposure, chlorpyrifos is absorbed directly into the systemic circulation and initially bypasses the liver.

These pharmacokinetic differences may play an important role in the route-specific toxicity of chlorpyrifos. In the absence of inhalation pharmacokinetic data, it is difficult to predict whether use of an oral NOAEL would over- or under-estimate inhalation risks.

Air Concentrations: There are also a number of uncertainties associated with the chlorpyrifos air concentrations used to assess termiticide risks, which affect both the 90 day and 1 year MOEs calculations. Measured chlorpyrifos air concentrations may be overestimated because of use of other chlorpyrifos-containing products. For example, more than half (55% or 17/31) of the homes in the DAS study had detectable chlorpyrifos air concentrations prior to termiticide treatment, indicating that residents may have used other chlorpyrifos products in the home, or had a previous chlorpyrifos termiticide treatment. Several studies in the scientific literature reported chlorpyrifos air concentrations up to 8 years following termiticide treatments (Wright et al. 1988, 1994). However, these studies did not control for use of other chlorpyrifos products (i.e., lawn treatment, flea control, or other indoor uses, etc) (personal communication by D. Smegal with G. Dupree 5/17/2000), and therefore, may also overestimate potential exposures and risks.

In addition, spills inside the home can contribute to higher airborne concentrations of chlorpyrifos. In the DAS study, one of the homes had elevated basement air concentrations because of a spill. The elevated basement measurements were excluded from the analysis (i.e., only kitchen and bedroom air data were used). This is considered reasonable because spills are likely to be an infrequent occurrence, and because pest control operators (PCOs) are trained to promptly clean spills that occur during application. However, possible applicator error, unreported, undetected or unremediated spills can contribute to air concentration measurements.

The available data suggest that temperature influences indoor chlorpyrifos concentrations resulting from termiticide treatments (i.e., warmer temperatures are associated with higher concentrations). In the DAS study, 26 of 31 homes were from the South or warm climates. Therefore, it is possible that the air concentrations used in this assessment represent high-end estimates, that could overestimate exposures for treated houses in more temperate climates.

There are uncertainties associated with the incremental TWAs air concentration calculations. Based on the mitigation plan, HED calculated the incremental TWAs by adjusting the air measurements associated with a 0.6-1.3% ai product application to 0.5% assuming that there is a linear relationship between percent ai and resulting air concentrations. This assumption is considered reasonable, although it could under- or over-estimate the air concentrations associated with 0.5% a.i. product application. In addition, the 1-year incremental TWA concentration may be overestimated for two basement homes, because one year air concentration measurements were not available. HED assumed the 90 day air concentration remained constant from 90 to 365 days. This assumption only impacts two basement homes (B1 and B2), both of which had 1 year MOEs less than 1000, but 90 day MOEs greater than 1000.

Air concentration measurements were taken in a total of 31 houses following termiticide

treatments. This limited number of houses is used to represent all houses in the US. There is inherent uncertainty in extrapolating from this limited sample size to the entire US. This may lead to an over- or underestimate of risk.

HED used of one-half detection limit for non-detects in calculating both the 90-day and 1-year incremental time-weighted averages (TWAs). This assumption may overestimate exposures slightly, particularly for the 1 year TWA estimates. However, this assumption is not likely to have a significant impact on the overall risk estimates, and has no impact on the homes with highest air concentrations (those homes had no non-detectable samples).

Exposure Assumptions. The assumptions used to estimate exposures are based on USEPA recommended values (Exposure Factors Handbook), and are designed to be conservative for the majority of the population. These estimates could be conservative for children that do not spend their entire day at home (i.e., those that attend day-care, pre-school, and/or school). This assessment assumed that children aged 1-6 years are exposed to chlorpyrifos air concentrations in a treated home for 20 hours/day, 7 days/week, for up to 1 year.

Summary: Based on the uncertainties described above, the 90 day risk estimates may be underestimated, while the 1 year risk estimates may be overestimated. As shown on Table 1, the lowest 90-day and 1-year MOEs for an individual house are 440 and 270, respectively and the highest estimates are 13,000 and 9,500, respectively. Although some MOEs are less than 1000, there is an additional 3 to 10 fold buffer because of the difference between the NOAEL and the LOAELs. In addition, a number of conservative assumptions were incorporated into these MOEs, such as assuming that all children spend 20 hours/day, 7 days/week for up to 1 year in a treated home.

Mitigation measures will further reduce exposures and risk. For example, the removal of whole house barrier treatment addressed the exposures of most concern. It is expected that the limited spot and localized treatment, and pre-construction treatments would represent less exposure and risk.

Table 1 Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment Reflecting Risk Mitigation to 0.5% ai (a)							
Home Type	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
Basement- Style Construction							
B1-KS	0.19	1,200	4,200	0.14	480	1,700	on

Table 1 Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment Reflecting Risk Mitigation to 0.5% ai (a)							
Home Type	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
B2-KS	0.20	1,100	3,900	0.22	310	1,100	off
B3-DC	0.03	8,600	30,000	0.03	2,500	8,500	off
B4-DC	0.03	6,500	23,000	0.03	2,400	8,200	on
B5-GA	0.37	600	2,100	0.25	270	930	on
B6-GA	0.16	1,400	4,700	0.11	560	2,000	unknown
B7-MA	0.03	8,700	30,000	0.03	2,500	8,800	on
B8-MA	0.04	6,200	21,000	0.04	1,600	5,700	on
Median (d)	0.1	3,800	13,000	0.07	1,100	3,800	
Crawl Space-style Construction							
C1-GA	0.23	950	3,300	0.20	340	1,200	off, first 7 days set to 0
C2-GA	0.03	7,200	25,000	0.04	1,800	6,200	on
C3-TX	0.18	1,300	4,300	0.13	520	1,800	on
C4-TX	0.14	1,600	5,500	0.18	380	1,300	off, first 7 days set to 0
C5-GA	0.21	1,100	3,600	0.16	430	1,500	unknown
C6-GA	0.08	2,600	9,100	0.12	540	1,900	unknown
C7-TX	0.03	5,900	20,000	0.03	2,100	7,400	on, first 7 days set to 0
C8-TX	0.04	5,100	18,000	0.03	2,100	7,300	on
Median (d)	0.11	2100	7,300	0.13	530	1,800	
Slab type Construction							
S1-TX	0.15	1,500	5,200	0.17	390	1,400	on
S2-TX	0.10	2,200	7,500	0.13	510	1,800	off
S3-TX	0.11	2,000	6,900	0.11	590	2,000	on

Table 1 Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment Reflecting Risk Mitigation to 0.5% ai (a)							
Home Type	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
S4-TX	0.10	2,200	7,500	0.09	760	2,600	off
S5-TX	0.04	5,800	20,000	0.03	2,200	7,600	off, first 7 days set to 0
S6-TX	0.21	1,100	3,700	0.24	280	960	off, first 7 days set to 0
S7-TX	0.51	440	1,500	0.11	600	2,100	off
S8-TX	0.12	1,800	6,300	0.08	880	3,000	off
Median (d)	0.12	1,900	6,600	0.11	600	2,100	
Plenum-style Construction							
P1-CA	0.36	610	2,100	0.13	500	1,700	---
P2-CA	0.08	2700	9,400	0.07	900	3,100	off
P3-CA	0.08	2700	9,500	0.09	760	2,600	off
P4-CA	0.03	6400	22,000	0.02	2700	9,500	off
P5-CA	0.20	1100	3,800	0.25	270	940	on
P6-CA	0.48	460	1,600	insufficient data (only up to day 30)	NE	NE	on
P7-CA	insufficient data (only up to day 7)	NE	NE	insufficient data (only up to day 7)	NE	NE	on
Median (d)	0.14	1900	6,600	0.09	760	2,600	

NE = Not evaluated

(a) MOEs rounded to 2 significant figures. Air concentrations adjusted from 0.6- 1.3% ai to 0.5% ai.

(b) House number in study and location.

(c) MOE = NOAEL/dose, where Dose calculated as follows: dose ($\mu\text{g}/\text{kg}/\text{day}$) = air conc ($\mu\text{g}/\text{m}^3$) * inhalation rate (m^3/day) * hours per day in house/24 hours * 1/body weight (kg). Assumptions are as follows: respiratory volumes of 13.3, and 8.1 m^3/day for an adults and 1-6 yr old child (average of male and female), respectively (Exposure Factors Handbook 1997 p. 5-24), and body weights of 70 and 15 kg, respectively. In addition, it assumes that adults and children spend 16.4 and 20 hours per day at home, respectively (Exposure Factors Handbook 1997 p.15-17, 15-147)

(d) Median MOE based on central tendency of MOE values, and not calculated based on median air concentration.

Table 2 Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment 0.6-1.3% ai Product Application							
Home Type	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
Basement- Style Construction							
B1-KS	0.334	670	2,300	0.248	270	930	on
B2-KS	1.013	220	760	0.793	84	290	off
B3-DC	0.052	4,300	15,000	0.054	1,200	4,300	off
B4-DC	0.068	3,300	11,000	0.0564	1,200	4,100	on
B5-GA	0.732	300	1,100	0.498	130	460	on
B6-GA	0.263	850	2,900	0.189	350	1,200	unknown
B7-MA	0.041	5,400	19,000	0.042	1,600	5,500	on
B8-MA	0.051	4,400	15,000	0.057	1,200	4,100	on
Median (d)	0.17	2100	7100	0.12	770	2700	
Crawl Space-style Construction							
C1-GA	0.562	400	1,400	0.477	140	480	off, first 7 days set to 0
C2-GA	0.059	3,800	13,000	0.07	940	3,300	on
C3-TX	0.317	700	2,400	0.232	290	1,000	on
C4-TX	0.279	800	2,800	0.35	190	660	off, first 7 days set to 0
C5-GA	0.359	620	2,100	0.266	250	870	unknown
C6-GA	0.178	1,200	4,300	0.259	260	890	unknown
C7-TX	0.061	3,700	13,000	0.049	1,300	4,600	on, first 7 days set to 0
C8-TX	0.07	3,200	11,000	0.05	1,300	4,600	on
Median (d)	0.23	1000	3500	0.25	270	940	

Table 2 Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment 0.6-1.3% ai Product Application							
Home Type	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu\text{g}/\text{m}^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
Slab type Construction							
S1-TX	0.179	1,200	4,300	0.2	330	1,100	on
S2-TX	0.165	1,300	4,700	0.21	320	1,100	off
S3-TX	0.2	1,100	3,900	0.20	330	1,100	on
S4-TX	0.165	1,300	4,700	0.14	480	1,700	off
S5-TX	0.061	3,600	13,000	0.05	1,400	4,700	off, first 7 days set to 0
S6-TX	0.374	590	2,100	0.43	150	530	off, first 7 days set to 0
S7-TX	0.91	240	850	0.2	330	1,200	off
S8-TX	0.22	1,000	3,500	0.137	490	1,700	off
Median (d)	0.19	1200	4100	0.2	330	1100	
Plenum-style Construction							
P1-CA	0.615	360	1,300	0.228	290	1,000	---
P2-CA	0.131	1,700	5,900	0.119	560	1,900	off
P3-CA	0.146	1,500	5,300	0.157	430	1,500	off
P4-CA	0.0657	3,400	12,000	0.046	1,400	5,000	off
P5-CA	0.407	550	1,900	0.492	140	470	on
P6-CA	0.948	230	810	insufficient data (only up to day 30)	NE	NE	on
P7-CA	insufficient data (only up to day 7)	NE	NE	insufficient data (only up to day 7)	NE	NE	on
Median (d)	0.28	1000	3600	0.16	430	1500	

NE = Not evaluated

(a) MOEs rounded to 2 significant figures. Air concentrations based on actual measurements in DAS study.

(b) House number in study and location.

(c) MOE = NOAEL/dose, where Dose calculated as follows: dose ($\mu\text{g}/\text{kg}/\text{day}$) = air conc ($\mu\text{g}/\text{m}^3$) * inhalation rate (m^3/day) * hours per day in house/24 hours * 1/body weight (kg). Assumptions are as follows: respiratory volumes of 13.3, and 8.1 m^3/day for an adults and 1-6 yr old child (average of male and female), respectively (Exposure Factors Handbook 1997 p. 5-24), and body weights of 70 and 15 kg, respectively. In addition, it assumes that adults and children spend 16.4 and 20 hours per day at home, respectively (Exposure Factors Handbook 1997 p.15-17, 15-147).

(d) Median MOE based on central tendency of MOE values, and not calculated based on median air concentration.

Comments on Pre-Construction Treatment:

Based on the available data for post-construction treatment and best professional judgement, HED concludes that pre-construction termiticide treatments are likely to result in lower chlorpyrifos indoor air concentrations and risk. This conclusion is based upon the following:

- (1) During pre-construction treatment, chlorpyrifos is applied to the soil and then is covered with a tarp, which would prevent volatilization into the house;
- (2) Treatment occurs before the house is built, and it is expected that air concentrations will decline dramatically during the 3 to 12 months of house construction;
- (3) New homes typically do not have cracks in the foundation that occur with settling to allow seepage into the house; and
- (4) There is no potential for spills or seepage from the drill holes in the foundation or slab, which could contribute to higher air levels following post-construction treatment.

References:

U.S. Environmental Protection Agency (USEPA). 1997. Exposure Factors Handbook. Volume III. Office of Research and Development, Washington, DC. p. 15-147. EPA/600/P-95/002Fc

Wright, C.G., Leidy, R.B., and Dupree, H.E., Jr. 1988. Chlorpyrifos in the Ambient Air of Houses Treated for Termites. Bull. Environ. Contam. Toxicol. 40:561-568.

Wright, C.G., Leidy, R.B., and Dupree, H.E., Jr. 1994. Chlorpyrifos in the Air and Soil of Houses Treated Eight Years after its Application for Termite Control. Bull. Environ. Contam. Toxicol. 52:131-134.

TABLE A-1. BASEMENT CONSTRUCTION																						
House	% ai	Volume	Locations	Pre-Treatment	Airborne Concentration (ug/m3) Post Application										0.7-1% ai		0.5% ai					
					During	2 Hours	4 Hours	8 Hours	24 Hours	1-day Avg	7 Days	30 Days	90 Days	1 Year	90 Day TWA	1 Yr TWA	90 Day TWA	1 Yr TWA				
			(gal)	Treatment																		
B1-KS 770F	0.9	85	Kitchen	0.16	0.2	0.18	0.2	0.42	0.11	0.222	0.16	0.22	0.08									
			Bedroom	0.14	0.12	0.17	0.14	0.17	0.1	0.14	0.2	0.1	0.12	no sample								
			Basement	0.19	0.27	0.7	0.63	0.57	0.55	0.544	0.54	1.1	0.45	allowed								
			Avg	0.16	0.20	0.35	0.32	0.39	0.25	0.30	0.30	0.47	0.22		0.334	0.248	0.186	0.138				
B2-KS 78 F	1	65	Kitchen	0.55	0.72	0.68	0.74	0.91	0.83	0.776	0.72	0.58	0.44									
			Bedroom	0.43	0.43	0.42	0.47	0.72	0.59	0.526	0.47	0.42	0.33	no sample								
			Basement	1.54	4.33	3.15	4.37	3.07	2.92	3.568	2.74	2.73	1.4	allowed								
			Avg	0.84	1.83	1.42	1.86	1.57	1.45	1.62	1.31	1.24	0.72		1.013	0.793	0.507	0.397				
B3-DC 75 F	1	186	Kitchen	<0.09	0.7	0.26	0.2	0.25	0.06	0.294	0.03	<0.06	<0.09	<0.09								
			Bedroom	<0.09	0.14	0.15	0.12	0.14	0.03	0.116	0.08	<0.07	<0.08	<0.08								
			Basement	<0.09	3.01	0.65	0.43	0.31	0.21	0.922	0.05	<0.08	<0.13	<0.09								
			Avg		1.28	0.35	0.25	0.23	0.10	0.44	0.05	0.04	0.065	0.045	0.0518	0.0542	0.0259	0.0271				
B4-DC 79 F	1	175	Kitchen	0.17	1.35	0.88	0.71	0.32	0.23	0.698	0.09	0.29	0.15	<0.08								
			Bedroom	0.13	0.19	0.26	0.35	0.26	0.08	0.228	<0.07	0.27	--	<0.08								
			Basement	0.2	3.48	2.64	1.97	0.89	0.4	1.876	0.2	0.41	0.14	<0.08								
			Avg	0.17	1.67	1.26	1.01	0.49	0.24	0.93	0.108	0.32	0.145	0.04	0.0681	0.0564	0.034	0.0282				
B5-GA 85 F	1	180	Kitchen	0.5	0.5	0.8	0.8	0.7	3.6	1.28	0.73	0.6	0.26	0.47								
			Bedroom	0.5	0.5	0.5	0.3	0.5	5.4	1.44	0.85	0.5	0.28	0.39								
			Basement	0.5	1.2	1.7	2.1	1.3	5.5	2.36	1.15	0.9	0.6	0.52								
			Avg	0.50	0.73	1.00	1.07	0.83	4.83	1.69	0.91	0.67	0.38	0.46	0.732	0.498	0.366	0.249				
B6-GA 0.8	0.8	170	Kitchen	0.03	0.35	0.39	0.33	0.35	0.24	0.332	0.52	0.2	0.16	0.13								
			Bedroom	0.09	0.11	0.13	<0.08	<0.08	<0.11	0.066	0.28	0.12	<0.08	<0.08								
			Basement	0.01	0.96	1.31	0.93	1.07	1.56	1.166	1.13	<0.25	0.37	0.24								
			Avg	0.04	0.47	0.61	0.43	0.49	0.6	0.52	0.64	0.15	0.19	0.14	0.263	0.189	0.1644	0.118				
B7-MA 33 F	0.8	185	Kitchen	<0.11	0.21	0.08	<0.08	<0.08	<0.07	0.08	<0.07	<0.07	<0.07	<0.09								
			Bedroom	<0.13	0.17	0.07	<0.08	<0.08	<0.08	0.071	<0.07	<0.07	<0.08	<0.09								
			Basement	<0.07	0.72	0.3	0.28	0.19	0.14	0.326	0.13	<0.08	<0.08	lost								
			Avg	0.065	0.37	0.15	0.12	0.09	0.07	0.16	0.067	0.04	0.04	0.045	0.0411	0.0422	0.0257	0.0264				
B8-MA 34 F	0.7	170	Kitchen	<0.01	0.3	0.14	1.2	<0.15	0.08	0.359	0.09	<0.07	<0.07	<0.07								
			Bedroom	<0.08	0.07	0.08	0.08	<0.11	<0.08	0.065	<0.07	<0.07	<0.07	<0.08								
			Basement	<0.1	0.7	0.07	0.31	0.45	0.34	0.374	0.15	0.07	<0.07	0.17								
			Avg	0.05	0.36	0.10	0.53	0.19	0.15	0.27	0.092	0.047	0.035	0.082	0.0505	0.0566	0.036	0.04				
														Median	0.166	0.1228	0.1	0.079				

TABLE A-2. SLAB CONSTRUCTION																		
House	% ai	Volume	Locations	Pre-Treatment	Airborne Concentration (ug/m3) Post Application										0.6-0.9% ai		0.5% ai	
					During	2 Hours	4 Hours	8 Hours	24 Hours	1-day Avg	7 Days	30 Days	90 Days	1 Year	90 Day TWA	1 Yr TWA	90 Day TWA	1 Yr TWA
		(gal)																
S1-TX 71oF	0.6	80	Kitchen Bedroom Avg	0.07 0.1 0.09	0.22 0.18 0.20	0.12 0.33 0.23	0.15 0.15 0.15	0.17 0.19 0.18	0.1 0.05 0.08	0.152 0.18 0.17	0.12 0.1 0.11	<0.08 0.12 0.08	0.37 0.39 0.38	<0.08 <0.09 0.045	0.179	0.204	0.149	0.17
S2-TX 70oF	0.8	98	Kitchen Bedroom Avg	0.09 0.09 0.09	0.27 0.29 0.28	0.08 0.14 0.11	0.08 0.08 0.08	0.13 0.07 0.10	0.19 0.17 0.18	0.15 0.15 0.15	0.13 0.13 0.13	0.08 0.08 0.08	0.32 0.32 0.32	0.17 0.09 0.13	0.165	0.21	0.103	0.13
S3-TX 85oF	0.9	95	Kitchen Bedroom Avg	<0.08 <0.08 0.04	0.37 - 0.37	0.41 0.12 0.27	0.47 0.07 0.27	0.3 0.09 0.20	0.25 0.1 0.18	0.36 0.095 0.23	0.21 0.09 0.15	0.2 <0.09 0.122	0.45 0.08 0.33	0.07 0.08 0.08	0.2	0.203	0.11	0.11
S4-TX 64oF	0.8	50	Kitchen Bedroom Avg	<0.08 <0.08 0.04	0.23 0.22 0.23	0.18 0.27 0.23	0.2 0.48 0.34	0.15 0.39 0.27	0.11 0.22 0.17	0.174 0.34 0.26	0.3 0.35 0.33	0.07 0.06 0.07	0.4 <0.09 0.22	<0.08 <0.09 0.045	0.165	0.14	0.103	0.0875
S5-TX 62oF	0.8	50	Kitchen Bedroom Avg	0.18 0.2 0.19	0.25 0.34 0.30	0.08 0.12 0.10	0.08 <0.07 0.058	0.08 <0.08 0.06	<0.09 <0.08 0.045	0.107 0.115 0.11	0.08 0.2 0.14	0.07 <0.08 0.055	<0.1 <0.12 0.055	<0.07 <0.08 0.035	0.0609	0.0489	0.038	0.0305
S6-TX 75oF	0.9	60	Kitchen Bedroom Avg	2.4 2.2 2.30	1.3 1.9 1.60	3.3 2.6 2.95	3.9 2.5 3.20	5.2 3.9 4.55	4.6 3.4 4.00	3.66 2.86 3.26	1 0.8 0.90	0.3 0.3 0.30	0.4 0.7 0.55	0.14 0.17 0.16	0.374	0.433	0.2078	0.24
S7-TX 77oF	0.9	60	Kitchen Bedroom Avg	0.35 0.32 0.335	1 1 1	1.4 1 1.2	1.6 1.3 1.45	1.6 1.5 1.55	1.2 0.7 0.95	1.36 1.1 1.23	0.7 0.8 0.75	0.4 0.4 0.4	0.2 0.2 0.2	0.11 <0.08 0.075	0.91	0.2	0.50	0.11
S8-TX 75oF	0.9	75	Kitchen Bedroom Avg	0.25 0.21 0.23	0.31 0.35 0.33	0.3 0.25 0.275	0.31 0.17 0.24	0.21 0.17 0.19	0.08 0.15 0.115	0.242 0.218 0.23	0.63 0.89 0.76	0.12 0.17 0.145	0.2 0.09 0.145	0.07 0.07 0.07	0.22	0.137	0.122	0.076
median															0.1895	0.20	0.117	0.112

TABLE A-3. CRAWL TYPE CONSTRUCTION

House	% ai	Volume	Locations	Pre-	Airborne Concentration (ug/m3) Post Application										0.6-1.3% ai		0.5% ai			
					During	2 Hours	4 Hours	8 Hours	24 Hours	1-day Avg	7 Days	30 Days	90 Days	1 Year	90 Day TWA	1 Yr TWA	90 Day TWA	1 Yr TWA		
				(gal)	Treatment	Treatment														
C1-GA 77oF	1.2	104	Kitchen	0.61		0.5	0.95	0.87	0.97	0.67	0.792	0.56	0.61	0.7	0.12	0.562	0.477	0.234	0.199	
			Bedroom	0.57		0.4	1	0.98	0.77	0.39	0.708	0.56	0.45	0.77	0.2					
			Avg	0.59		0.45	0.98	0.93	0.87	0.53	0.75	0.56	0.53	0.74	0.16					
C2-GA 81oF	1, 0.9	106	Kitchen	<0.07	<0.07	0.07		0.07	0.07	0.06	0.061	0.08	0.07	0.08	0.08	0.059	0.071	0.031	0.037	
			Bedroom	<0.07	<0.07	0.07		0.08	<0.08	<0.07	0.052	<0.08	<0.07	0.08	0.05					
			Avg	0.035		0.035	0.07	0.08	0.055	0.048	0.06	0.06	0.05	0.08	0.07					
C3-TX 103oF	0.9	203	Kitchen	0.02		0.35	0.44	0.6	0.34	0.28	0.402	0.18	<0.08	0.36	0.08	0.317	0.232	0.176	0.129	
			Bedroom	0.03		0.03	0.23	--	0.03	0.08	0.0925	0.12	0.73	0.3	0.08					
			Avg	0.03		0.19	0.34	0.60	0.19	0.18	0.25	0.15	0.385	0.33	0.08					
C4-TX 68oF	1	129	Kitchen	0.08		0.1	0.08	0.08	0.08	0.08	0.084	<0.08	0.08	0.77	<0.08	0.279	0.35	0.1395	0.175	
			Bedroom	0.08		0.1	0.08	0.08	0.12	<0.08	0.084	<0.09	0.08	0.65	<0.08					
			Avg	0.08		0.10	0.08	0.08	0.10	0.06	0.084	0.043	0.08	0.71	0.04					
C5-GA NA	0.6, 1.1	170	Kitchen	0.01		0.2	0.32	0.7	0.89	0.17	0.456	0.57	0.34	0.27	0.25	0.359	0.266	0.211	0.156	
			Bedroom	<0.1	0.15		0.24	1.02	1.15	0.25	0.562	0.87	0.35	0.17	0.25					
			Avg	0.03		0.18	0.28	0.86	1.02	0.21	0.51	0.72	0.35	0.22	0.25					
C6-GA NA	0.8, 1.3	130	Kitchen	<0.08	0.72		0.82	0.76	0.69	0.08	0.614	0.52	0.07	0.25	0.33	0.178	0.259	0.0847	0.123	
			Bedroom	<0.08	0.36		0.58	0.4	0.32	0.11	0.354	0.08	0.1	0.23	0.33					
			Avg	0.04		0.54	0.70	0.58	0.51	0.10	0.48	0.30	0.09	0.24	0.33					
C7-TX 35oF	0.8	43	Kitchen	<0.2	<0.2	<0.08	<0.1	<0.14	<0.1	0.048		0.16	0.08	0.08	<0.06	0.0606	0.0498	0.0379	0.0311	
			Bedroom	<0.1	<0.2	<0.1	<0.09	<0.14	<0.09	0.062		0.06	<0.07	<0.09	<0.06					
			Avg	0.15		0.1	0.05	0.05	0.07	0.05	0.055	0.11	0.0575	0.0625	0.03					
C8-TX 35oF	0.8	45	Kitchen	0.12		0.12	0.19	<0.13	0.23	0.45	0.211	0.17	<0.08	<0.09	<0.08	0.0699	0.05	0.04	0.03	
			Bedroom	0.13		0.25	0.18	0.17	0.19	0.13	0.184	0.17	<0.08	<0.09	<0.09					
			Avg	0.125		0.185	0.185	0.1175	0.21	0.29	0.1975	0.17	0.04	0.045	0.043					
			median										0.2285	0.2455	0.112					0.126

TABLE A-4. PLENUM CONSTRUCTION TYPE HOMES

House	% ai	Volume	Locations	Pre-Treatment	During Treatment	Airborne Concentration (ug/m3) Post Application										0.8-1% ai		0.5% ai	
						2 Hours	4 Hours	8 Hours	24 Hours	1-day Avg	7 Days	30 Days	90 Days	1 Year	90 Day TWA	1 Yr TWA	90 Day TWA	1 Yr TWA	
P1-CA 100oF	0.8, 0.9	NA	Kitchen Bedroom Avg	<0.06 <0.06 0.03	0.1 0.42 0.26	0.1 1.8 0.95	1.2 2 1.60	0.33 1.9 1.12	1.8 1.8 1.80	0.706 1.584 1.15	0.8 1.38 1.09	0.74 0.59 0.67	0.1 0.21 0.16	<0.08 <0.08 0.04	0.615	0.228	0.3617	0.134	
P2-CA 42oF	0.8, 0.8	200	Kitchen Bedroom Avg	0.05 <0.05 0.038	0.28 0.12 0.20	0.28 0.22 0.25	0.4 0.14 0.27	1.81 0.72 1.27	0.33 0.96 0.65	0.62 0.432 0.53	0.36 0.22 0.29	0.07 0.07 0.07	0.13 <0.06 0.08	0.09 0.2 0.15	0.131	0.119	0.082	0.074	
P3-CA 61oF	0.9, 0.9	35	Kitchen Bedroom Avg	0.07 0.07 0.07	0.21 0.8 0.51	0.08 0.12 0.10	0.21 0.14 0.18	0.11 0.08 0.10	0.1 0.14 0.12	0.142 0.256 0.20	0.07 0.12 0.10	0.24 0.15 0.20	0.17 0.07 0.12	0.23 0.17 0.20	0.146	0.157	0.0811	0.087	
P4-CA 54oF	1, 0.9	NA	Kitchen Bedroom Avg	<0.06 <0.07 0.04	<0.1 <0.1 0.05	0.32 0.77 0.55	0.41 0.63 0.52	0.48 0.65 0.57	0.33 0.45 0.39	0.318 0.51 0.414	0.08 0.08 0.080	<0.08 <0.08 0.04	<0.08 <0.08 0.04	n o t available 0.04	0.0657	0.0464	0.0346	0.0244	
P5-CA 75oF	1	125	Kitchen Bedroom Avg	<0.08 <0.08 0.04	1.3 3.2 2.25	0.2 0.16 0.18	0.3 0.45 0.38	0.25 0.24 0.25	0.29 0.2 0.25	0.468 0.85 0.25	0.36 0.51 0.44	0.36 0.3 0.33	0.46 0.57 0.52	not available 0.52	0.407	0.492	0.20	0.246	
P6-CA 65oF	0.99	100	Kitchen Bedroom Avg	0.4 0.3 0.35	3.2 1.7 2.45	3.7 3 3.35	5.8 3.6 4.70	1.5 0.9 1.20	1.7 1.4 1.55	3.18 2.12 2.65	0.4 0.3 0.35	1.3 0.8 1.05	not available 0.8	N o t available 0.8	0.948	not calculated	0.479	not calculated	
P7-CA 63oF	1	60	Kitchen Bedroom Avg	<0.08 <0.08 0.04	4.05 10.4 7.23	6.7 6.1 6.4	6 6.3 6.15	6.2 5.2 5.7	4.7 4.3 4.5	5.53 6.46 6.00	6.8 2.6 4.7	Not available			not calculated	not calculated	not calculated	not calculated	
P8-CA 53oF	0.8	90	Kitchen Bedroom Avg	No Data											median	0.2765	0.157	0.143	0.087